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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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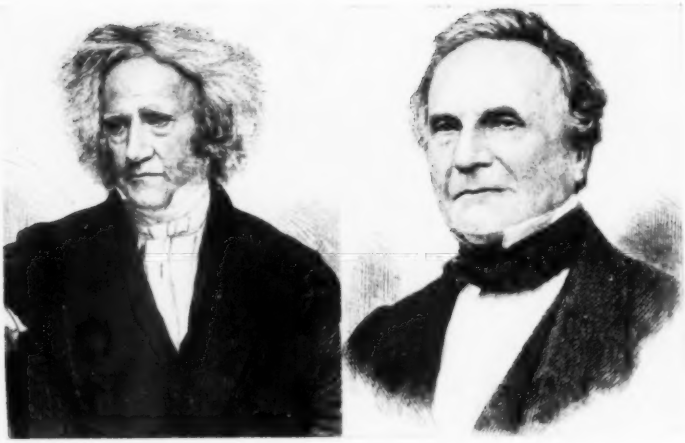
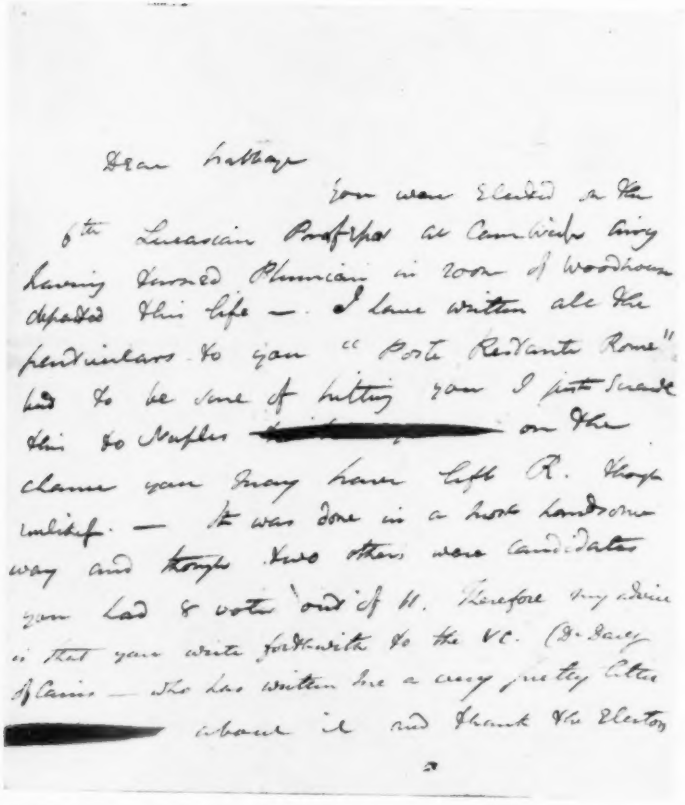
PLATE III



JOHN F. W. HERSCHEL CHARLES BABBAGE

Both born 1792 and died 1871.



Dear Babbage

You were Elected a the
6th Lucasian Professor at Cambridge being
having favored Physician in room of Woodhouse
deceased this life — I have written ale the
particulars to you "Poste Restante Rome"
but to be sure of hitting you I just send
this to Naples [redacted] on the
chance you may have left R. though
unlikely — It was done in a most handsome
way and though two others were candidates
you had 8 votes out of 11. Therefore my advice
is that you write forthwith to the VC. (Dr. Davy
of Caius — who has written me a very pretty letter
[redacted] about it and thank the Electors

2

First page of a Letter sent by Sir John Herschel to Charles Babbage, dated March 9, 1828.

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TWO LETTERS OF A FAMOUS ASTRONOMER

By C. A. CHANT

(With Plates III, IV)

TWO original letters, of interest in the history of astronomy, recently came into possession of the Royal Astronomical Society of Canada. Both were written by Sir John Herschel to Charles Babbage in 1828 and were presented to the Society by the latter's great-grandson Mr. Richard H. Babbage, a Montreal journalist and member-at-large. These letters were among some of Charles Babbage's papers and books given to Mr. Babbage in 1917 by his grandfather (the late Major-General H. P. Babbage, Indian Army) while visiting England in the course of service overseas as a battery officer in the Canadian Corps Artillery.

Charles Babbage (December 26, 1792-October 18, 1871) was born in Devonshire and became a student at St. Peter's College, Cambridge. He was especially famous as a mathematician and for his calculating machines. From 1828 to 1839 he was Lucasian professor of mathematics at Cambridge, a chair which Newton had occupied. In the founding of the (Royal) Astronomical Society in 1820 he had the leading part, although John Herschel was associated with him from the beginning. He was prominent in organizing the British Association for the Advancement of Science in 1831; and he is also credited with being the original proposer and founder of the (Royal) Statistical Society in 1834.

Babbage and Herschel were born in the same year, were students at Cambridge together, and died in the same year. In the *Monthly Notices* for 1871 it is remarked: "Sir John Herschel and Mr. Babbage were the last survivors of the small band of scientific men who met together at the Freemasons' Tavern January 12th, 1820,

'to take into consideration the propriety and expediency of establishing a Society for the encouragement and promotion of astronomy', a meeting which resulted in the foundation of the Royal Astronomical Society."

J. F. W. Herschel (March 7, 1792-May 11, 1871) was the only child of Sir William Herschel. He entered St. John's College, Cambridge, at the age of 17 and graduated senior wrangler in 1813 with Peacock (afterwards Dean of Ely) second. While undergraduates Herschel, Peacock and Babbage entered into a compact that they would "do their best to leave the world wiser than when they found it", and this noble undertaking they all carried out successfully to the end.

Herschel achieved distinction in many fields of labour, and his life was full of high endeavour. "Whatever he touched he adorned." He had no jealousies and steered clear of all scientific feuds, but was the object of universal admiration. He was buried in Westminster Abbey near Newton.

One of the letters was written for Babbage to present to Cacciatore, an Italian astronomer at Palermo, and is in French. It is printed here as nearly as possible just as it was dashed off by its author.

Niccoló Cacciatore was born January 26, 1770, in Castel-termine in the southern part of Sicily. In 1798 he went to reside with the astronomer Piazzi in Palermo and in 1800 he was appointed assistant at the Royal Observatory there. It was here that Piazzi on January 1, 1801, discovered the first asteroid. Cacciatore was a capable astronomer and in 1817 succeeded Piazzi as director of the observatory. He died January 28, 1841.

The two letters, which contain references to several persons well known in the history of astronomy, are printed below.

Letter written on March 9, 1828, by J. F. W. Herschel to Charles Babbage. The postmark is Colnbrook, Buckinghamshire, England.

Dear Babbage,

You were elected on the 6th Lucasian professor at Cambridge, Airy having turned Plumian in room of Woodhouse departed this life. I have written all the particulars "Poste Restante Rome" but to be sure of hitting you I just scrawl this to Naples on the chance you may have left Rome, though unlikely.

It was done in a most handsome way and though two others were candidates you had 8 votes out of 11. Therefore my advice is that you write forthwith to the V.C. (Dr. Davey of Caius) who has written me a very pretty letter about it and thank the electors in good set terms and tell him you will be back in time to examine for the next Smith's prize or any other time as much earlier as you please—as your presence at the Board of Longitude will be very acceptable (of which you are as you [are] aware now, a member, virtute officei).

I refer for particulars to my letter at Rome which if you return by Rome you cannot miss. Remember me to Monticelli more kindly.

Yours truly, in great haste,

(Signed) J. F. W. Herschel.

Slough, March 9, 1828.

Letter of introduction to Professor Cacciatore of Palermo, Sicily, given to Charles Babbage by J. F. W. Herschel, written in 1828. This letter was not presented because Babbage did not visit Sicily, through delay in Naples.

Mon cher monsieur,

Cette lettre vous fera porter par Mons Babbage, le secretaire de notre Societe astronomique pour la correspondance etrangere. Je vous fera fait de tous ce que nous faisons dans votre science ici. De votre part—ayez le bonte pour l'amitie qui vous portez moi—de le recevoir avec bienviellance. Il est extremement interesse (comme le sommes tous nous autres) sur les travaux importans que vous occupere si dont vous avez publie des resultats si interessant dans le volume de vos observations envoye au Capt. Smyth. Capt. S. va etablir une observatoire pres de Bedford—il aura des instruments que lui a fourni la societe astronomique—donc j'espere il fera bon emploi.

Struve a publie un *ouvrage magnifique* dans son catalogue de 3112 etoiles doubles fait avec le grand telescope de Fraunhofer a Dorpat. Ce sera pour lui un titre pour l'immortalite.

Adieu mon cher monsieur. Faites mes compliments a monsieur votre frere—et a Signor Taunton et

Croyez moi votre tres fidele

(Signed) J. F. W. Herschel.

N.B. C'est Mons Babbage qui a invente cette celebre machine pour calculer les tables donc on a tout parle.

P.S. Longtemps avant l'arrive de cette lettre j'espere que vous aurez bien vos chronometres.

P.P.S. Ayez le bonte pour l'avenir de m'addresser vos *lettres* non pour le secretaire de la societe ni astronomique ni Royale—mais simplement pour M. Herschel, Slough, Colnbrook, Bucks, Angleterre. Si quant aux *livres*, etc., vous pouvez me les addresser par le moyen du Secretaire du Bureau des Longitudes, Dr. Young, London.

THE FOURTH ANNUAL AWARD OF THE CHANT MEDAL

By H. R. KINGSTON
(Chairman of the Committee)

The Chant Medal is awarded each year to an amateur for outstanding contributions to astronomy. The fourth annual award has been made to Mr. Cyril Geoffrey Wates of Edmonton. He was sponsored for this honour by Dr. J. W. Campbell of the University of Alberta and Dr. Andrew McKellar of the Dominion Astrophysical Observatory, for valuable contributions to the art of telescope construction, culminating in the 12½-in. "Pyrex" reflector which he made and which, in May 1943, he presented to the University of Alberta. An account of the presentation was given in the September 1943 number of the JOURNAL.

Mr. Wates is a man of many hobbies but it was his interest in practical things—in constructing, refining and operating them—which led to his present honour. As Maintenance Engineer of the Edmonton Municipal Automatic Telephone System he has a "bent" and an experience which not only initiated his hobby of telescope making but have also enabled him to obtain a marked success in it for himself and also to render aid to the amateur in building his own telescope. A few of Mr. Wates' contributions will be mentioned here along with a bibliography of articles which he has written on various other phases of telescope construction during the past few years.

One of the attractions of telescope making for the amateur is the fact that so much can be accomplished with simple equipment or with tools which may not be so simple but which may, however, be constructed at a very low cost. For grinding and figuring small telescope mirrors no machine is necessary since one's hands accomplish the desired results so readily. However, if a machine can be built to replace the handwork, much labour may be saved. Moreover, there is a satisfaction in construcing an instrument that will do the work even though little or no time may be saved by it. An excellent machine for grinding, figuring and polishing mirrors, which is known as the Hindle type, was constructed at a very low cost by Mr. Wates from discarded parts of washing machines, automobiles, dental engines, etc. He used this instrument for figuring and polishing the 12½-in.

mirror of the University of Alberta telescope. The quality of this mirror has been proved by its excellent performance during the past year.

An important feature of mirror construction is the testing of the mirror at every step of the process. During the figuring it is not sufficient that every zone be made to have the same focal length, but each zone must merge smoothly with its neighbours. Hence a graph of the surface is necessary. For obtaining this graph at any stage of the figuring, Mr. Wates devised a method which is independent of the use of mathematics and therefore makes possible more accurate results for the non-mathematical amateur.

Many persons, after using for a time a telescope which does not automatically follow the motion of the sky, become tired of the continual hand-shifting of the instrument and dream of a simple motor or clock attachment which will relieve them of this task. However, the construction of such a machine presents so many difficulties that the idea is often given up as not worth the trouble involved. Mr. Wates designed an inexpensive solution of the problem, in which the power is supplied by a variable motor controlled by a pendulum clock. The motor operates a lathe screw whose motion is transferred by a steel tape to a pulley on the polar axis.

An idea of the range of Mr. Wates' interests in the field of telescope construction may be obtained from the foregoing and from the following list of topics of articles which he has written in the past few years for the *Scientific American*: A 9-in. Telescope (Oct. '35); Design for Setting Circles (May '36); Simple Finders (July '36); Notes on the Foucault Test (Sept. '37); Mathematics of Diagonal Secondaries (Sept. '37); Notes on Diagonals (Sept. '38); Ronchi Gratings (May '39); The Gaviola Test (March '40); Collimation (Oct. '40); Design for Diagonal Mounting (Oct. '40); Use of Star Laps (Oct. '41); Tests for Contact (Aug. '42); Tests for Right Angled Prisms (Jan. '43); Collimating a Springfield Mounting (June '43).

It should be added here that another facet of Mr. Wates' interests is indicated by an article in this JOURNAL (Sept. '42) entitled "Time, Space and Meaning".

Mention has already been made of the 12½-in. telescope which

Mr. Wates constructed and presented to the University of Alberta. This is only one of six telescopes ranging in size from 4-in. to 12½-in. which came from his hands and which bear eloquent testimony not only to his interest and ability but also to his tireless energy.

The great company of amateur telescope builders on this continent and elsewhere will wish to join in congratulating Mr. Wates on his accomplishments in his chosen hobby and in the honour that has come to him with the Chant Medal, and also in expressing their appreciation of his efforts to share with others the experience which he has gained. Further, it is their fervent hope that he may long be spared in health and strength to pursue and enjoy his avocation and to bring inspiration and happiness to many.

London, Ont.

A TRIBUTE TO THE WINNER OF THE CHANT MEDAL FOR 1943

By E. H. Gowan

At the regular meeting of the Edmonton Centre on March 9, 1944, a short period was used to pay tribute to Mr. C. G. Wates, the recipient of the Chant Medal for 1943.

The Chairman, Dr. A. J. Cook, addressed the meeting as follows:

We are happy to welcome Mr. Cyril G. Wates to this meeting of the Centre, after his pardonable absence from the last meeting. And I am sure he will accept the heartiest felicitations from all of us on the occasion of his marriage. We extend our welcome tonight for yet another reason, namely, to record our appreciation of the great honour that has come to him, in recognition of his outstanding services to Canadian amateur astronomy. As we all know, the Chant Medal for 1943 has been awarded to Mr. Wates. A letter received from the General Secretary of the Society by Mr. Wates containing official notification of the award and the medal was forwarded to him subsequently.

It is with great pleasure, therefore, that I call upon the Honorary President of the Edmonton Centre, Professor J. W. Campbell, to suitably express on our behalf our appreciation of the well-merited distinction which has been conferred upon Mr. Wates.

The remarks of Dr. Campbell were as follows:

At a meeting of the General Council of the Royal Astronomical Society of Canada in March, 1940, there was established a silver medal to be known as the Chant Medal. The purpose was twofold—to give some tangible recognition to the long and distinguished services of Professor C. A. Chant, the Dean of Canadian Astronomers, by thus commemorating his name, and to give recognition to outstanding achievements by amateur astronomers. To be awarded the Chant Medal is therefore a truly great honour, and it was with pride that we learned a few weeks ago that this distinction had come to the nominee of the Edmonton Centre, Mr. Cyril G. Wates.

To quote from the resolution establishing the medal, the award is "to be made on the basis of the value of the work which he has carried out in astronomy and closely allied fields of original investigation." On this basis the local executive had no hesitation in nominating Mr. Wates. He has had a zealous interest in astronomy over many years. He has pursued with meticulous care the construction of instruments by which the joys of observation could be experienced by himself and by a wide circle of friends, and a long list of articles published in the *Scientific American* attest to his mechanical skill and insight.

His little private observatory across the road from his house on the bank of the Saskatchewan River has been a rendezvous for many a group. Those groups will long remember the kindly interest with which he assisted them in their observations, and also the hospitality extended in his home.

His crowning achievement, of course, was his construction of the 12.5 inch telescope which he donated to the University of Alberta. It was fortunate, indeed, that we had two professional astronomers with us for the opening of the Observatory last May—Dr. J. A. Pearce and Dr. A. McKellar of the Astrophysical Observatory at Victoria. Both Dr. Pearce and Dr. McKellar attested their admiration for the high order of skill and workmanship shown in the construction, and for the excellent quality of performance by the mirror. This instrument is already proving a great stimulus to astronomy, not only in our Society but also in the public at large, and it will stand as a permanent emblem of the achievement and generosity of Mr. Wates.

We, his fellow members of the Edmonton Centre, wish to put on record our hearty congratulations to him for having received the Chant Medal. By winning this award he has brought distinction not only to himself, but also to our Centre, to Edmonton and to Alberta.

Dr. Cook then stated that it had been hoped President Newton would be present for this occasion, but pressure of other work made this impossible. A letter from Dr. Newton to the Honorary President had expressed his regrets for his inability to attend, and had conveyed congratulations to Mr. Wates. The following excerpt from the letter was read by Dr. Cook: "I hope you will extend my congratulations to Mr. Wates on behalf of the University. Since he gave us his reflecting telescope, which he continues to elaborate and demonstrate to University audiences, we feel almost as though he were one of ourselves and that we have a share in the well merited honour which has come to him."

Mr. Wates made the following reply:

Not only would it be ungracious, it would also be untrue to pretend that I an not deeply and sincerely gratified at having received the award of the Chant Medal. When Dr. Campbell approached me on behalf of the Centre, for permission to submit my name, I was naturally flattered, but I had no expectation that the members of the Committee would consider my slight accomplishments worthy of the award. When I was officially notified that the much-coveted Chant Medal was actually mine, I was still more surprised. Medals and similar honours are generally awarded for difficult and arduous accomplishments, especially those that are carried out in the spirit of unselfish service. In this case, I seem to have been awarded the greatest honour in Canadian amateur astronomical circles simply for enjoying myself! I took

up astronomy in the first place solely for the pleasure I expected to get from it, and I have continued to pursue this noblest of all sciences in much the same state of mind. If, in the process of having a good time, I have brought pleasure to others, that is my good fortune, and is due to no merit of mine.

In military, and especially in Naval circles, individuals often receive medals which everyone, including the recipient, recognize as justly belonging to a group who shared equally in the deeds for which the award was made. I feel that a somewhat similar condition exists in the case of the Chant Medal. Scattered throughout Canada are many amateur astronomers whose merits are as great as, or greater than, mine. It has been my happy lot to correspond with a number of these, and to learn something of the steady, unremitting work they are devoting to the science of Astronomy. Night after night, in warm weather and cold, these men are at the eyepieces of their telescopes, probing the secrets of the universe and, little by little filling in details of knowledge which are beyond the scope of the great observatories, with their narrowly restricted programmes of research. I wish to extend the hand of fellowship to these workers, and to express the hope that they may share some of the pleasure I feel in being the holder of this magnificent award. Many of them are my friends, and have aided me in my own work along these lines.

I am afraid that I shall never be a really skilled observer. Frankly, I find my greatest pleasure in trying to teach others something of the wonders I have been able to see for myself, rather than to make any original discoveries. To hear the awe-stricken exclamation of wonder from the lips of a child who, for the first time, sees the glory of the Perseus Clusters or the grandeur of the Sinus Iridum; to answer the questions of Mr. and Mrs. Average Citizen when they glimpse the splendours of Saturn or the fairylike sheen of the Orion Nebula—these are sufficient reward for many hours of exacting labour at the polishing bench and the testing table.

I thank the Committee for having given me the award; I thank Dr. Campbell and Dr. Newton for their expressions of appreciation and good-will; but above all I thank the host of amateur astronomers, whether known to me personally or not, for laying the pathway which has led me by such easy and enjoyable steps to this delightful climax. I have been a mountaineer and an astronomer. Mountains and Stars alike call out our finest aspirations. In the words of the motto of the Alpine Club of Canada: "Sic Itur Ad Astra"—thus we go to the Stars!

The medal was then projected on the screen by means of a reflecting lantern, and later those present were given an opportunity to examine it in turn.

PRESENTING ALBUM OF LETTERS TO DR. S. A. MITCHELL, UNIVERSITY OF VIRGINIA, MAY 11, 1944

By John Calvin Metcalf

SOME months ago a committee of seven of his scientific colleagues conceived the idea of presenting to Samuel Alfred Mitchell, on the eve of his retirement,* an Album of Letters. It was a happy thought. A man often hesitates to go to a friend and tell him what he thinks of him. He might, of course, say it with flowers, but they soon wither, and besides, flowers sometimes carry a mortuary suggestion, and Mitchell is still very much alive. But in a letter one may not only express one's affection or admiration more freely but also more artistically. Moreover, letters are permanent records to be read again and again. In a sense the letters in this Album are fraternal love letters. They constitute a friendship's garland, a token of regard for what you are and for what you have done. They tell you a good many things you already knew and some things you didn't know and may be surprised to learn. They come from various sources, including church and state. One of them is a brief and charming filial letter from a young scientist by your own name. The sentiments expressed in this volume will have, I believe, an exhilarating effect upon the spirit, enabling you to grow old buoyantly—let me pronounce it boy-antly. If you ever get depressed in this new leisure that will be yours, read these letters and renew your youth. They may help you to realize, in spite of a rheumatic pain or two, that you are only seventy years young.

Just that many years ago the future astronomer appeared upon this planet in the Canadian section of it, and so he was born a good American. After taking his master's degree at Canadian Queen's University, he gravitated southward for his doctorate at Johns

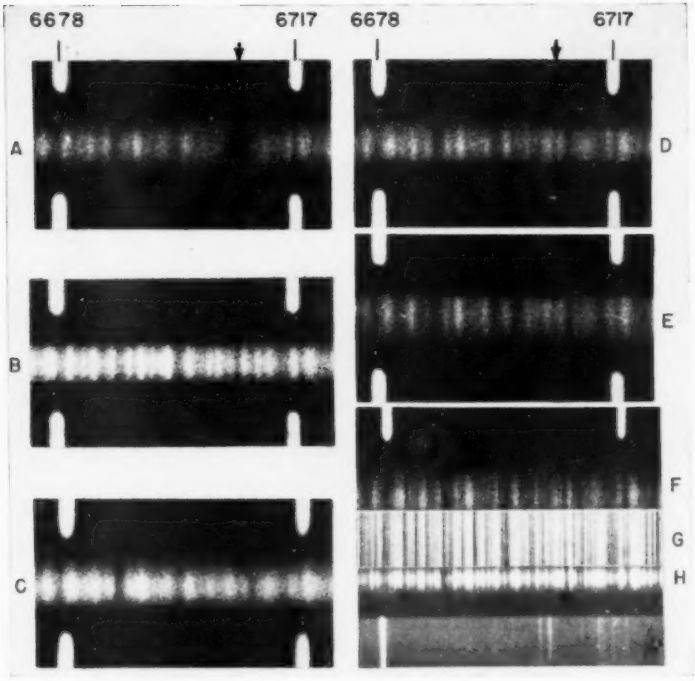
*The news of the "retirement" of Professor Mitchell seems to be grossly exaggerated. He is to continue in active service as professor and as director of the Leander McCormick Observatory.—*Editor.*

Hopkins, and then, for thirteen or fourteen years, he taught astronomy at Columbia. From that university he came to Virginia thirty years ago. Of these fruitful years as teacher, scholar, author, world-traveler as eclipse specialist, member of national and international societies—of all these varied activities it is hardly necessary for me to speak, for they are known to you. We take pride in the many honours that have come to him because of his contributions to science, his interest in research, his usefulness as a citizen and as director of a great observatory. All these have brought honour and distinction to this University. I take this public occasion, Dr. Mitchell, to express my own indebtedness to you as a member of the Graduate Committee during my fourteen years of ex-officio chairmanship of that committee. You always stood for sound and progressive scholarship and high standards.

The scientist and the humanist are often spoken of as very different species of the genus homo. Well, such a dichotomy of culture, as the philosophers might say, I do not accept. You recall Huxley's famous remark that science is "nothing but trained and organized common sense". It involves a good deal more, however, than technical knowledge. Perhaps you may also remember John Dewey's assertion that "every great advance in science has issued from a new audacity of imagination". I am myself too ignorant of science to make comparisons between one physical science and another, but it seems to me that the astronomer in particular must ground his observations in both trained common and un-common sense, whose ultimate flowering is "a new audacity of the imagination". Though Dr. Mitchell has soared much among the stars and has taken many telescopic flights among the planets, he has not yet acquired what the theosophists call an "astral body". Whether he is piercing the astronomical stratosphere above Mt. Jefferson or Mt. Wilson or Tin Can Island in the far-off Pacific, he keeps his feet pretty firmly upon the good earth. And let us hope that his translation to some heavenly body, however fit he may be for that exalted state, is still far off. As Horace said to Augustus: *Serus in coelum redeas*—may you return late to the sky.

It gives me uncommon pleasure, Dr. Mitchell, as a longtime friend and academic associate, to present to you this Album of Letters from this and other lands. Their beautiful setting in this luxurious binding enriches the gift. Along with this presentation goes the hope that you may long continue your scientific activities, your interest in research and in the dissemination of that branch of human knowledge to which your life has been so fruitfully devoted. *Accipe pro amicitia.*

PLATE V



SPECTRA OF THE CARBON STARS AND OF CN IN THE λ6700 REGION

(A) H.D. 224855 (WZ Cas); (B) H.D. 110914 (Y CVn); (C) H.D. 192443 (RS Cyg); (D) H.D. 7561 (Z Psc); (E) H.D. 76221 (X Cnc); (F) H.D. 223075 (19 Psc); (G) Laboratory spectrum of CN as photographed by Dr. A. S. King; (H) H.D. 223075 (19 Psc) as photographed by Dr. R. F. Sanford with the Coudé Spectrograph at the Mount Wilson Observatory (original dispersion 5.9 A per mm.).

THE RESONANCE LINES OF LI I AND NA I IN SPECTRA OF THE RED CARBON STARS

By A. McKellar* and W. H. Stilwell

(With Plate V)

Introduction

THE yellow and red regions in the spectra of stars of spectral types R and N were first surveyed by Hale, Ellerman and Parkhurst[1] at the beginning of the century, were later examined by Shane[2] and still more recently by Sanford[3] and by Keenan and Morgan.[4] In these regions the spectra of the cool carbon stars are extremely complex yet, despite their complexity, are remarkably alike from star to star. No notable degree of success was attained in identifying the multitude of absorption lines present until Merrill,[5] in 1933, found that the near infra red spectra of stars of this class were almost identical with a negative reproduction of the laboratory emission spectrum of the molecule CN as produced in a King-type electric furnace. Following this, Sanford[3] showed that for the red spectral region a similar almost exact identity held between the stellar spectra and that of CN. At shorter wave lengths, from the yellow down, C_2 absorption begins to play the major role and numerous atomic lines are evident.

In 1940, one of the present writers[6] noted that in the spectrum of the N-type variable, WZ Cas, the resonance doublet of Li I occurred with great strength. Spectrograms of four other stars of similar spectral type inspected at that time did not exhibit any appreciable absorption feature at λ6707.84, the position of this lithium line. These spectrograms had been obtained using the three-prism form of the Victoria spectrograph[7] which gives dispersions of 50 and 30 A per mm. at λ6700 and λ5890, respectively. The presence of the intense lithium line in the spectrum WZ Cas thus seemed to present an anomaly which justified a more detailed examination of the λ6708 region in the spectra of other stars of similar type. It was clear that the three prism spectrograph referred to above, while it would reveal a line of moderate strength, say 1.5A or more in equivalent width, was not sufficiently powerful to enable

*At present on leave of absence from the Observatory.

the detection of a relatively weak line at λ6708. Consequently, it was decided to use the grating with camera of 27 inches focal length for as many stars as possible. Relative to the three prisms, this form of the spectrograph[7] gives much higher resolving power and

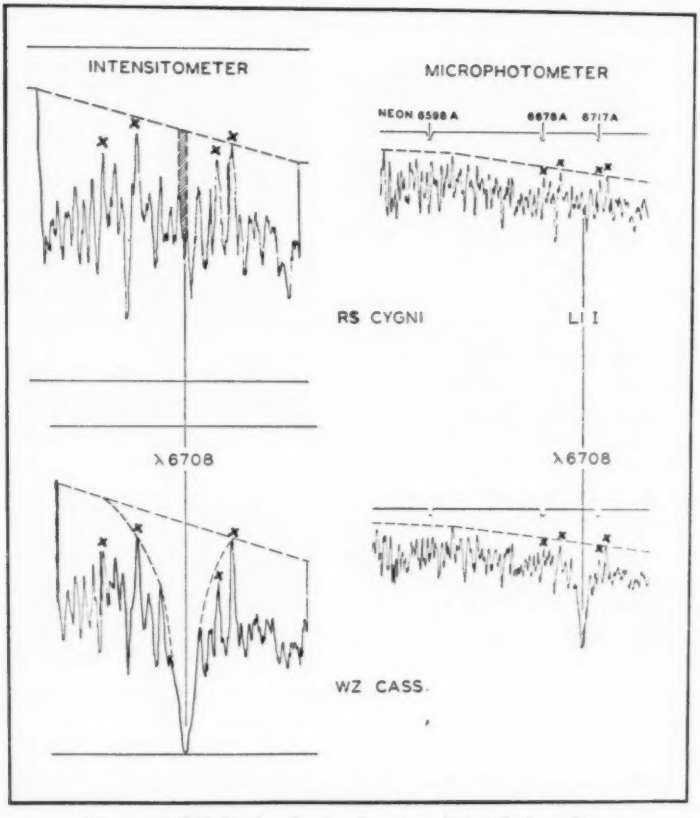


Fig. 1. λ6708 Region in the Spectra of the Carbon Stars.

dispersion, the latter being nearly linear with wave length and, at λ6700, having the value, 18.3 A per mm. Nearly four-fifths of the plates studied were secured with the grating.

The D-lines of Na I and the λ6708 doublet of Li I arise from strictly analogous $^2P - {}^2S$ transitions and in the spectrum of WZ Cas not only is the λ6708 Li I line intense but the Na I D-lines occur with very great strength. Therefore it was thought of possible interest and profit to study the λ5893 (D-line) region on our spectrograms as well as the λ6708 region. In this paper the results of measurements of wave length and intensity in the latter region and of the intensities of the sodium D-lines, for forty-two stars, are presented. The conclusions to be drawn from these measurements,

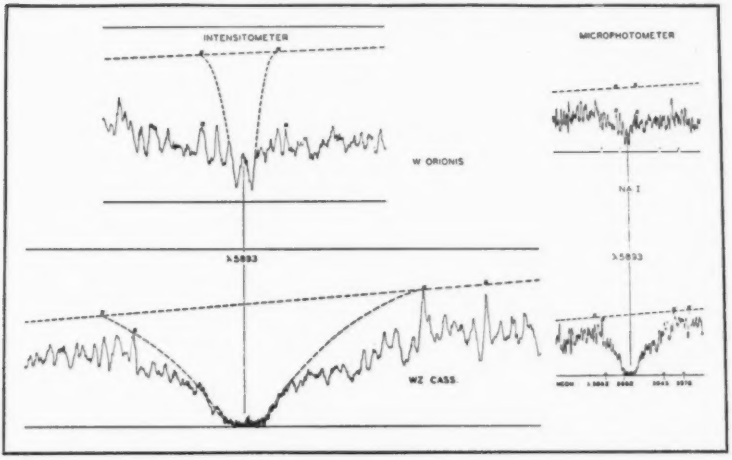


Fig. 2. λ5893 Region in the Spectra of the Carbon Stars.

particularly in connection with the presence of lithium in the atmospheres of the red carbon stars, are then given consideration. A preliminary report on this subject dealing with twenty stars was presented at a meeting of the American Astronomical Society in June, 1942.[8]

The Observations and Measurements

The total number of spectrograms upon which measurements were made was sixty-one. Forty-nine of the plates were obtained with the grating and represent observations on thirty stars. The

remainder, obtained with three prisms, comprised one plate of each of twelve additional somewhat fainter objects. Depending on the brightness of the star, the spectrographic slit-width employed varied from 0.050 to 0.100 mm., with the most usual value being 0.075 mm. Almost all of the spectra were photographed on Eastman 103-F emulsion.

Early in this investigation it was noted that on the grating plates there occurred in every case a definite absorption line near λ6707.8, although it could not be observed for certain on the three-prism spectra. This conclusion was substantiated by Dr. R. F. Sanford of the Mount Wilson Observatory who, in June 1941, informed us that he had measured a line in the spectrum of H.D. 223075 (19 Piscium) at λ6708 and that he considered it to be the Li I resonance line. In our investigation no star other than WZ Cas was found in which λ6708 was an intense line. However, very recently Sanford[9] has found it to occur with considerable strength on plates of the star WX Cygni, an object which, on account of its faintness, was not on our program, so has not been observed at Victoria. The line is somewhat less intense than for the case of WZ Cas but very much stronger than for any other star yet examined. Hence, of over forty red carbon stars observed to date, only spectra of WZ Cas and WX Cyg show a notably strong Li I resonance line.

From our grating plates, measurements both of the wave length and intensity of the λ6708 line and of the intensity of the sodium D-lines were carried out. The twelve three-prism plates were utilized only for the purpose of making intensity measurements on the D-lines, although they served to show that none of the spectra of those twelve stars had strong λ6708 lines. Microphotometer tracings of the grating spectra were made and from these, using the semi-automatic intensitometer designed and recently described by Beals,[10] true intensity curves of the λ6708 and λ5890 regions were obtained. For the former region magnifications along the direction of dispersion of 100 and 2, respectively, were used for the two instruments, so the dispersion on the intensity curve was 200 times that of the original plates, or 0.09 A per mm. For the λ5890 region, successive magnifications of 20 and 4 gave a resultant of 80 times the original.

The wave-length measurements were made on the intensitometer

tracings using as a basis of reference a scale obtained from all the intensitometer tracings of the spectrum of WZ Cas. This scale, on tracing linen, showed the mean positions of the λ6708 line for WZ Cas and of about six definite absorption features to the red of this line and an equal number to the violet. By superposing it on the intensitometer tracings, the wave length of the λ6708 feature in the spectra of all the stars was measured relative to the wave length for WZ Cas. To obtain the zero point of this scale, namely the wave length of λ6708 in the spectrum of WZ Cas, the seven best plates of this star were measured with the micrometer. Also, the seven corresponding microphotometer curves (upon which occurred tracings of the comparison lines) were measured. These gave, respectively, values of 6708.02 and 6708.07A. To ensure that the wave lengths for all the stars should not rely solely on the radial velocity for WZ Cas, five grating plates of the stars W Ori, UU Aur, Y CVn and 19 Psc were measured with the micrometer and the wave lengths so obtained compared with those found for these stars from the tracings. A correction of +0.05A was in this way deduced and applied to the measurements made on the tracings. Thus, the final wave lengths given for the λ6708 line in the last column of Table I depend on micrometer measurements of spectra of the five stars mentioned in this paragraph.

The weighted mean value of the wave length of the λ6708 line from the forty-nine plates is 6707.68 ± 0.01A. Dr. Sanford has informed us that measurements on thirty-five grating spectrograms obtained at Mount Wilson yield a mean wave lengh of 6707.71A, which is satisfactorily close to the above. These wave lengths are definitely shorter than the laboratory value for Li I which is 6707.84A.[11] Also, the mean wave length for WZ Cas is somewhat longer than this laboratory value. These points will be discussed in the next section of the paper.

The wave length of the prominent λ6103 line in the spectrum of WZ Cas is of interest in connection with the identification of λ6708 with lithium. In normal N-type spectra, the wave length found by Sanford for the $4^3P - 5^3S$ line of Ca I (lower E.P. = 1.871 volts) was 6102.81A, the laboratory value being 6102.73A. For WZ Cas this line seems unusually strong, and from seven plates we measure the wave length as 6103.08 ± 0.02A. This high value

seems almost certainly due to blending with the first member of the diffuse series of Li I ($2^2P - 3^2D$, lower E.P. = 1.840 volts) at λ6103.64, and so provides confirmatory evidence of the correctness of the lithium identifications. This blending effect for WZ Cas has also been suspected by Sanford.

The intensity measurements were carried out using the new intensitometer referred to above.[10] Incidentally, each plate had been calibrated using a rapidly rotating step-sector. The intensitometer curves were operated on by a planimeter to give the total intensities of the λ6708 line and the sodium D-lines.

For stellar spectra of type N in the red region, the absorption lines are so numerous and the resulting pattern so complex that it is not difficult to understand why some earlier investigators considered the isolated sharp regions of continuous spectrum as emission lines. Deciding where to draw the continuous background is not easy. To demonstrate the complexity of the spectra, to illustrate typical microphotometer and intensitometer tracings and particularly to indicate where the continuous spectrum was taken, two figures are presented. Figure 1 shows tracings of the λ6708 region for the stars WZ Cas and RS Cyg. The λ6708 line and four adjacent intensity maxima are indicated on each. The approximately horizontal dotted lines show the positions chosen as representing the continuum. All the narrow λ6708 lines were drawn in as shown in the top-left part of the figure, with vertical sides rising from the maxima on each side of the line centre. This seemed the best way in which to divide up the general absorption caused, doubtless, by the "wings" of the multitude of closely packed absorption lines. Figure 2, showing the D-line region for WZ Cas and W Ori, is similar to Figure 1.

The results of the intensity measurements are given in Tables 1 and 2. In connection with these results, a number of points may be emphasized, including:

(1) The greatest source of systematic error in the measurements probably arises in choosing the continuous spectrum.

(2) Nearly all the stars are variables, so possibly the strengths of the sodium and lithium resonance lines in their spectra vary. While for each star generally only one or two plates have been measured, the means for all the stars should be significant as average equivalent widths for the red carbon stars.

(3) The equivalent widths constitute a more homogeneous body of data than the central intensities, because they are not influenced by the different slit-widths used (0.050 to 0.100 mm.).

The mean equivalent width for all the stars of the sodium D-lines ($D_1 + D_2$), is 13A and for the lithium resonance line (after taking into account blending with CN, discussed in the next section, and evaluating it as 0.5A) is 0.6A.

In connection with Tables I and II, it may be mentioned that the stellar magnitudes have been mainly obtained from Schneller's *Catalogue and Ephemerides of Variable Stars for 1939* (Klein. Veroff. Univ. Stern., Berlin-Babelsberg). Material on spectral types has been obtained largely from Sanford's[3, 9] and from Keenan and Morgan's publications.[4] The "C" classification recently proposed by the latter not being available for all the stars, we have estimated it for the remainder using the last three of the four criteria proposed by Keenan and Morgan. Our estimates are those enclosed in parentheses.

Discussion and Conclusions

Reproductions of the λ6700 region in the spectra of six carbon stars and of CN are shown in Plate V. All except G and H were made from the grating plates studied. G is a portion of the electric furnace spectrum of CN obtained at the Mount Wilson Observatory laboratory by Dr. Arthur S. King and H a high dispersion (5.9A per mm.) spectrogram of 19 Piscium obtained by Dr. R. F. Sanford using a fine-grained plate with the Mount Wilson coudé grating spectrograph. The λ6708 line is indicated by a dot in each case. A comparison of G and H illustrates how very much alike the N-type stellar spectrum and laboratory CN spectrum are in this region, the important point discovered and discussed some years ago by Merrill and by Sanford. The large number of coincidences shows that in this region the stellar absorptions are nearly all due to CN. Incidentally, spectrum G is very purely that of CN. For example, there is no evidence of the λ6707.84 line of lithium, which does appear in the spectrum of CN produced by an arc between commercial carbons.

The main point to be settled, if possible, is whether the line we have measured λ6707.68 (and Sanford at λ6707.71) indicates the

TABLE I—MEASUREMENTS ON THE λ6708 LINE AND THE SODIUM D-LINES FROM GRATING SPECTROGRAMS

No.	Star	Magnitude	Spectral Type	No. of Plates	Sodium D-Lines			λ6708 Line		
					Equivalent Width (D_1+D_2)	Central Intensity D_1	Central Intensity D_2	Equivalent Width	Central Intensity	Wave Length
1	H.D. 1546 = VX And	8.1– 9.5	N7 : ($C5_4$)	1	5.8A	0.40	0.40	1.0A	0.61	6707.58A
2	2342 = AQ And	6.9– 8.2	Nb : ($C5_3$)	2	8.4	0.26	0.22	1.1	0.44	.58
3	7561 = Z Psc	6.9– 8.1	N0 : $C7_3$	2	12.9	0.10	0.10	0.6	0.60	.76
4	19557	8.1	R5 : $C4_3$	1	7.8	0.13	0.12	1.4	0.27	.51
5	22611 = U Cam	6.9– 9.0	N5 : ($C6_4$)	1	8.7	0.17	0.16	0.9	0.47	.65
6	25408 = UV Cam	7.9–	R8 : $C5_3$	1	8.5	0.15	0.13	1.5	0.40	.73
7	31996 = R Lep	6.0–10.4	N6e : $C7_4$+*	1	8.5	0.17	0.17	0.7	0.54	.88
8	32736 = W Ori	5.9– 7.7	N5 : $C5_3$	2	10.8	0.14	0.14	0.8	0.51	.63
9	38307 = Y Tau	6.5– 8.9	N2 : ($C7_4$)	1	13.7	0.15	0.08	0.6	0.55	.54
10	42272 = TU Gem	7.4– 8.3	N3 : ($C5_3$)	1	12.6	0.12	0.09	0.8	0.33	.61
11	44984 = BL Ori	4.7– 6.6	Nb : ($C6_2$)	1	13.3	0.00	0.01	0.8	0.52	.73
12	46687 = UU Aur	5.1– 6.8	N3 : $C5_3$	2	15.7	0.14	0.13	1.0	0.42	.65
13	76221 = X Cnc	5.9– 7.5	N3 : $C5_4$	1	11.8	0.12	0.10	0.7	0.56	.62
14	92839	6.3	N0 : $C6_3$	1	9.2	0.24	0.22	0.9	0.32	.66
15	110914 = Y CVn	4.8– 6.0	N3 : $C5_4$	2	11.1	0.10	0.08	1.4	0.24	.66
16	112559 = RY Dra	6.1– 7.1	N4p : $C4_4$	2	8.2	0.16	0.15	1.5	0.19	.62
17	141826 = V CrB	6.9–12.4	N3e : $C6_3$*	1	10.0	0.27	0.28	0.5	0.40	.65
18	173291	8.1	N4 : $C6_4$	1	10.7	0.25	0.25	0.7	0.62	.61
19	174325 = S Sct	7.0– 8.0	N3 : $C5_4$	1	8.2	0.41	0.36	0.8	0.44	.71
20	177336 = V Aql	6.7– 8.2	N6 : $C6_4$	1	5.9	0.47	0.42	0.6	0.61	.62
21	183556 = UX Dra	5.8– 7.2	N0 : $C7_3$	1	14.6	0.01	0.00	1.2	0.31	.73
22	186047 = TT Cyg	7.3– 8.9	N3 : ($C6_4$)	1	9.3	0.29	0.26	0.7	0.59	.69
23	189256 = AX Cyg	7.4– 7.9	Nb : ($C7_4$)	1	11.1	0.13	0.14	0.8	0.49	.65
24	192443 = RS Cyg	6.8–10.3	N0pe : $C8_2$*	2	41.0	0.03	0.03	0.9	0.52	.81
25	V Cyg	6.8–13.8	Npe : ($C7_4$)*	1	12.4	0.12	0.08	0.8	0.36	.52
26	206362 = S Cep	7.0–12.9	N8e : $C7_4$*	1	12.5	0.18	0.19	0.6	0.57	.65
27	206570 = DS Peg	6.0– 7.0	N1 : $C6_3$	2	11.1	0.08	0.13	0.9	0.42	.67
28	223075 = 19 Psc	5.3	N0 : $C6_2$	3	15.3	0.07	0.05	0.7	0.39	.80
29	224855 = WZ Cas	6.9– 8.5	N1p : $C9_1$	10	55.7	0.01		8.4†	0.04	6708.05
30	225217 = SU And	7.9– 8.5	Nb : ($C5_5$)	1	10.2	0.05	0.07	1.0	0.25	6707.60

*These spectrograms exhibit *Hα* in emission.

†This is the equivalent width for WZ Cas corrected for the effect of the presence of the moderately strong line at λ6709.9.

presence of neutral lithium in the atmospheres of the cool carbon stars. The mean wave length, as already noted, is definitely lower than that of the Li I doublet found in the laboratory to be λ6707.84. From measurements on King's original high-dispersion laboratory plates of CN, Sanford has found a CN line at λ6707.512. It's red edge is at λ6707.57 and the clear space between it and the CN line

TABLE II—SODIUM D-LINE INTENSITIES IN THE SPECTRA OF STARS, IN ADDITION TO THOSE OF TABLE I, OBSERVED WITH THE THREE PRISM SPECTROGRAPH.

	Star	Magnitude	Spectral Type	Intensity of Sodium D-lines		
				Equivalent Width (D_1+ D_2)	Central Intensity D_1	D_2
1	H.D. 30243 = ST Cam	6.9– 8.3	N5: $C6_4$	14.5A	0.07	0.05
2	B.D. 15° 726	9.4	N : (C_{-1})*†	56.	0.05	
3	H.D. 36602 = RT Ori	7.5– 8.9	Nb :	‡		
4	51620 = RV Mon	7.0– 8.2	Nb : $C5_4$	8.0	0.18	0.18
5	52432	7.5	R5 : $C4_4$	8.7	0.25	0.26
6	56167 = RU Cam	7.8– 9.0	R0 : $C0_1$*	3.1	0.57	0.50
7	T Cnc	8.0–10.2	N3 : $(C5_3)$	7.6	0.29	0.24
8	77234	9.5	R5 : $(C4_4)$	5.2	0.45	0.32
9	92055 = U Hya	4.5– 6.3	N2 : $C7_3$	14.1	0.03	0.01
10	108105 = SS Vir	7.2– 9.0	Np : $C6_3$*	10.1	0.14	0.04
11	156074	7.7	R1 : $C1_2$	5.3	0.49	0.34
12	T Lyr	7.8– 9.6	N3 : $C6_5$	6.1	0.42	0.34

*$H\alpha$ appears as an emission line.

†B.D. 15° 726 is difficult to classify. The intensity distribution in its spectrum appears to correspond to C4 or C5 whereas the great strength of the sodium D-lines would place it at C8 or C9.

‡The plate, although well enough exposed at λ6708, was not sufficiently strong at λ5890 to allow accurate measurement of the intensity of the D-lines.

of next longest wave length is 1.4A. The λ6707.512 CN line is clearly shown in reproduction G, Plate V. It appears to be of slightly shorter wave length than the λ6708 line in the spectrum of 19 Piscium, H, and one-third to one-half as intense, relative to the other CN lines present. Doubtless this CN line is present in the

λ6709.9.

spectra of the carbon stars generally, and there it would blend with λ6707.84 of Li I. In fact, that blend appears to be what has been measured in this study. We conclude, therefore, that for all the stars where the equivalent width of the λ6707.68 line is above about 0.5A, there is a contribution to it by the ultimate line of neutral lithium. Thus, from Table 1, it would appear that for over two-thirds of the stars examined, lithium absorption is present.

A case of blending in the spectrum of WZ Cas, where the lithium identification has already been shown to be corroborated by the behaviour of λ6103, is of interest. The intense lithium line has been measured on seven plates and their tracings as λ6708.05, some 0.2A to the red of the laboratory value. This seems a consequence of blending with the fairly strong line at λ6709.9 which is seen to the right of λ6708 in all the spectra of Plate V except A. The complete identification of this line is not known, although from Plate V, G and H, it appears partly due to CN. It's mean equivalent width as determined from plates of six stars is 1.5A. This was taken into account in arriving at the intensity of λ6708 for WZ Cas, given in Table I.

The original purpose in measuring the line intensities was in part to see if any correlation existed between those for λ6708 and the sodium D-lines. The Na I and Li I resonance lines arise from similar transitions, the atomic constants such as ionization potential are almost the same (5.13 and 5.38 volts), so if the relative abundance of sodium to lithium were constant, such a correlation might be expected over limited ranges of temperature and pressure. Plots of intensities of λ6708 against $(D_1 + D_2)$ using data in Table 1, and also of line intensities against the R-N and more recent C classifications were made. Due perhaps partly to the blending effects already discussed and to the small number of measurements on each star, the results did not appear very definitive. For WZ Cas, both Li I and Na I resonance lines are strong. However, spectra of HD 192443 (RS Cyg) and B.D. $+15°\ 726^{12}$ (our attention was directed to the latter star by Dr. W. W. Morgan of the Yerkes Observatory) exhibit very strong D-lines but weak λ6708.

The question as to whether the intense Li I resonance line in spectra of WZ Cas (and WX Cyg) is due to unusually high abundance of lithium or to low excitation conditions, is an interesting

one. The former possibility was advanced by one of the authors when the strong line in WZ Cas was first noted[6] and the latter was more recently suggested by Keenan and Morgan.[4] While the data on RS Cyg and B.D. +15° 726 compared with the case of WZ Cas, cited in the previous paragraph, indicate the possibility of different relative abundances for sodium and lithium, the present material cannot be said to settle the point. Although classified by Keenan and Morgan as the coolest red carbon star, WZ Cas is certainly not the reddest one. Further observations of various sorts leading to excitation and colour temperatures will be required in this connection.

Summary

A study of the λ6708 and λ5890 regions on spectrograms of over forty red carbon stars obtained at Victoria, supplemented by data from Dr. R. F. Sanford obtained at Mount Wilson, indicates that:

(1) Spectra of nearly all these stars show evidence of absorption by Li I atoms at λ6707.84 although blending with a CN line at λ6707.51 gives the resultant mean wave length 6707.68. Only two stars show really strong Li I absorption.

(2) The average equivalent width for the sodium D-lines in all these spectra is $(D_1 + D_2) = 13$A, and for the lithium resonance doublet, correcting for the above blending effect, is 0.6A.

(3) The available data on line intensities show no marked correlation between Na I and Li I resonance line intensities or between spectral types and intensities of these lines.

(4) The present material does not enable a definite decision to be reached upon whether the very great strength of the Li I ultimate line in the spectrum of WZ Cas is a consequence of unusual abundance of lithium or of low excitation conditions.

In conclusion we wish to acknowledge our indebtedness and to express our thanks to Dr. R. F. Sanford of the Mount Wilson Observatory for making available to us unpublished data which were of the greatest significance and value in this study.

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THE SPECTROGRAPHIC BINARY, LAMBDA ANDROMEDAE

By Elizabeth C. Walker

CAMPBELL[1] discovered the binary nature of this star in 1899, and a series of fifty-six three-prism spectrograms were secured at the Lick Observatory, the first eighteen with the original Mills spectrograph, 1898-1902, and the remaining thirty-eight with the new Mills instrument, 1904-1906. Keivin Burns[2] investigated the orbit and obtained a separate set of orbital elements for the two series of observations. He found a change of 1.1 ± 0.2 km sec. in the systemic velocity and a difference of $35°.2 \pm 10°.8$ in the value of ω. These were interpreted as real changes in the line of apsides and the systemic velocity.

Luyten[3] in 1934 suggested that the binary was a simple two-body system. By a graphical method he obtained a preliminary set of elements but did not compute a least-squares correction to them. Definitive orbital elements for the 1898-1906 Lick Observatory observations were derived by J. A. Pearce[4] in 1943, who applied the systematic corrections to Burns' velocities suggested by Campbell and Moore,[5] and assembled the observations on a revised value of the period obtained from observations recently secured at this observatory after an interval of 35 years. These elements are shown in Table V.

The Victoria Orbit of Lambda Andromedae

To investigate the questions of a possible rotation of the line of apsides, Dr. Pearce placed the star on his programme of repeat orbits in 1938. Twenty-seven spectrograms were secured from J.D. 2422881 to J.D. 2430722, thirteen of which were IIL plates having a dispersion of 11.0 A/mm., two were IL plates having a dispersion of 22.0 A/mm., and twelve were IM plates, dispersion of 30.1 A/mm. at Hγ. In general, Astra II emulsion was used, the average observing time for the II-prism plates being 67 minutes, and for the I-prism plates, 26 minutes.

[1]W. W. Campbell, Ap. J., *10*, 178, 1899.
[2]K. Burns, L.O.B., *4*, 87, 1906.
[3]W. J. Luyten, Publ. Univ. Minn., *II*, 19, 1934.
[4]J. A. Pearce, R.S.C., *37*, 111, 1943.
[5]Campbell and Moore, Pub. L.O., *16*, xxii, 1928.

The spectrum of Lambda Andromedae is of type G6, containing many sharp metallic lines. An interesting feature of the spectrum is the occurrence of the H and K lines of ionized calcium in emission. Their velocities were at first omitted, but when shown to be in excellent agreement with the velocities of the absorption lines were subsequently included. For the II-prism plates, twenty-eight lines, principally of FeI, Mn I and H I, free from blends, were selected for measurement. For the I-prism plates in which the blending was more serious, the number of lines was reduced to twenty. An inspection of the line residuals indicated the necessity of adopting adjusted wave lengths for half a dozen lines. All of the spectrograms were measured by Dr. J. A. Pearce and the writer.

To insure that the adopted wave lengths of the velocity standards would satisfactorily reproduce the velocities of the standard stars, and to investigate a possible personal equation between the measurers, series of ten single-prism and ten two-prism plates of the standard velocity stars Alpha Tauri and Alpha Bootis were measured.

TABLE I

SYSTEMATIC AND PERSONAL EQUATIONS

Standard Stars	*Pearce–Star*	*Walker–Star*	*Pearce–Walker*
Aldebaran, Arcturus			
10, II-prism plates..	-0.03 ± 0.33	$+0.15 \pm 0.31$	-0.18 ± 0.45 km./sec.
10, I-prism plates...	$+0.55 \pm 0.28$	$+0.31 \pm 0.34$	$+0.24 \pm 0.44$ "

The above results clearly indicated that the adopted wave lengths were satisfactory and that no appreciable personal equation existed between the two observers, whose measures were combined with equal weight.

The observations are given in Table II, where the columns are as follows: (1) Number, (2) Camera employed, (3) Observer, (4) Julian date, (5) Phase from final T, (6) Observed radial velocity, (7) Number of lines, (8) Relative weight, (9) Final residual, (10) and (11) the velocity and number of calcium lines. At the time of measurement each measurer weighted the velocity according to the quality and number of the lines measured. The relative weight used in the orbit depended upon the weight of the plate and the dispersion, II-prism plates being given double the weight of I-prism plates. The higher dispersion observations had approximately three-quarters of the total weight of the solution.

TABLE II—Observations of Lambda Andromedae

No.	Camera	Obs.	Julian Date 2400000+	Phase from T	Radial Velocity	No. of Lines	Weight	(O-C) km/sec.	Calcium Velocity	No. of Lines
1	IM	Y	22881.963	0.103	+10.75	12	0.4	−0.98	+10.1	2
2	IM	Y	22995.718	11.252	1.14	16	0.6	−0.12	0.0	2
3	IIL	Pe	29114.990	15.207	0.91	25	2.8	−0.69	5.6	2
4	IIL	Pe	29125.988	5.683	11.07	26	3.0	+0.53	12.0	2
5	IIL	Pe	29135.959	15.654	1.78	17	2.0	−0.40	....	.
6	IIL	Pe	29163.866	2.519	14.82	22	2.4	+1.19	....	.
7	IL	Pe	29495.934	6.248	7.76	20	1.2	−1.78	8.2	2
8	IL	Pe	29496.937	7.252	7.36	16	0.7	−0.29	....	.
9	IM	WP	29513.826	3.619	12.56	18	0.5	−0.62	11.8	2
10	IM	Pe	29516.684	6.477	8.64	18	0.6	−0.48	8.6	2
11	IM	Pe	29516.727	6.520	8.99	20	0.8	−0.05	9.3	2
12	IM	WP	29519.814	9.607	3.13	18	0.6	−0.25	−0.4	2
13	IM	S	29520.874	10.667	1.47	20	0.7	−0.42	+4.5	2
14	IIL	Pt	29524.874	14.667	2.17	20	2.2	+1.13	....	.
15	IM	M	29525.904	15.697	1.98	20	0.7	−0.26	1.0	2
16	IIL	W	29531.808	1.079	13.23	27	2.8	+0.27	13.3	2
17	IM	M	29541.866	11.137	2.06	21	0.8	+0.69	3.5	2
18	IM	S	29547.745	17.016	4.16	19	0.6	−0.34	5.0	2
19	IIL	Pt	29550.776	20.047	10.12	25	2.8	−0.64	11.0	2
20	IM	S	29561.687	10.437	2.70	19	0.8	+0.52	4.4	2
21	IM	S	29566.708	15.458	1.62	18	0.5	−0.30	3.4	2
22	IIL	W	29568.711	17.461	5.97	25	2.6	+0.58	7.4	2
23	IIL	W	30718.685	18.248	7.38	18	1.6	+0.32	7.2	2
24	IIL	Pe	30719.558	19.121	8.92	19	2.0	−0.01	7.9	2
25	IIL	Pe	30719.635	19.198	8.99	18	1.8	−0.10	10.1	2
26	IIL	Pe	30722.560	1.602	13.53	22	2.4	+0.16	15.0	2
27	IIL	Pe	30722.628	1.670	13.13	20	2.4	−0.28	16.6	2

M = McKellar; Pe = Pearce; Pt = Petrie; WP = W. Petrie; S = Stilwell; W = Wright; Y = Young.

TABLE III—NORMAL OBSERVATIONS

No.	Weight	Final Phase	Observed Velocity	Calculated Velocity	Final (O–C)
1	7.6	1.4311	+13.29	+13.26	+0.03
2	2.9	2.7089	14.43	13.61	+0.82
3	3.0	5.6833	11.07	10.54	+0.53
4	2.6	6.3848	8.34	9.29	−0.95
5	0.7	7.2523	7.36	7.65	−0.29
6	0.6	9.6073	3.13	3.38	−0.25
7	2.9	10.8545	1.90	1.68	+0.22
8	5.0	14.9697	1.46	1.34	+0.12
9	3.2	15.6331	1.80	2.15	−0.35
10	3.2	17.3779	5.63	5.22	+0.41
11	1.6	18.2483	7.38	7.06	+0.32
12	3.8	19.1578	8.95	9.01	−0.06
13	3.2	20.1194	10.20	10.89	−0.69

THE SOLUTION

The time of periastron passage T = J.D. 2429202.1774 was taken at approximately the mean of the Victoria observations, and a period of P = 20.5212 days was adopted and omitted from the solution. The twenty-seven observations were combined into the thirteen normal places given in Table III and a preliminary representation made by the elements:

$e = 0.080$; $\omega = 308°.0$; $V_o = +6.89$ km/sec.;
and K = 6.66 km/sec.

A least-squares solution, by the Lehman-Fihlés method, reduced Σpvv from 10-45 to 8.08, a 23% reduction.

Normal Equations:

v	w	x	y	z	n
+40.3000	+ 6.2646	− 0.9390	−11.3347	−12.0086	−0.2980 = 0
	+20.9674	+ 8.1560	− 0.1217	− 0.3640	+2.9113
		+22.1339	− 0.4307	+ 0.1805	+5.6174
			+21.1214	+22.0946	+3.3469
				+23.6200	+3.4362

The solution of the above normal equations gave the following corrections to the elements:

$v = \delta V_0 = -0.0478$ $\quad \delta V_0 = -0.05$ km/sec.
$w = \delta K = -0.0175$ $\quad \delta K = -0.02$ km/sec.
$x = K\delta e = -0.2655$ $\quad \delta e = -0.040$
$y = -K\delta\omega = -0.6455$ $\quad \delta\omega = +5°.55$
$z = 2.05890\ \delta T = +0.4358$ $\quad \delta T = +0.2117$ days

TABLE IV

ORBITAL ELEMENTS OF LAMBDA ANDROMEDAE

Element		Lick Observatory Observations 1898-1906 (Pearce)	D.A.O. Observations 1938-1942 (Pearce, Walker)
Period	P	20.5212 ± 0.0003 days	20.5212 ± 0.0003 days
Periastron Passage(J.D.)	T	J.D. 2416314.864 ± 0.497	J.D. 2429202.389 ± 0.476
Eccentricity	e	0.084 ± 0.014	0.040 ± 0.024
Periastron minus node	ω	308°.2 ± 9°.14	313.6 ± 8.94
Velocity of System	V_0	+6.89 ± 0.06 km/sec.	+6.84 ± 0.12 km/sec.
Semi-amplitude	K	6.66 ± 0.10 km/sec.	6.64 ± 0.17 km/sec.
	$a \sin i$	1,875,000 km.	1,872,000 km.
	$\frac{m_2^3 \sin^3 i}{(m_1+m_2)^2}$	.0006 ⊙	.0006 ⊙
No of observations		51	27
Probable error of observation of average weight		±0.54 km/sec.	±0.45 km/sec.

A final representation of the individual observations gave the residuals shown in column 9 of Table II. The probable error of a single observation of average weight was $\pm$ 0.45 km/sec., somewhat smaller than that of $\pm$ 0.54 km/sec. for the III-prism Lick Observatory observations.

The elements of the two orbits of this star are given in Table IV. It will be seen that in every case the elements are in exact agreement, within their probable errors, indicating beyond a doubt that no changes have occurred during the 35-year interval.

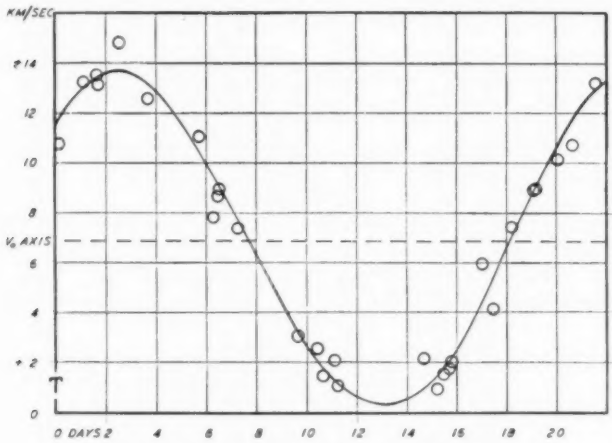

FIG. 1. THE RADIAL VELOCITY CURVE OF LAMBDA ANDROMEDAE.

The Victoria observations are plotted upon the radial velocity curve, figure I, the diameter of the plotted indices representing the probable error of a single observation of average weight.

Victoria, B.C.
January 1944.

REVIEW OF PUBLICATIONS

Introductory Astronomy by J. B. Sidgwick. 137 pages, 6 by 9 in. N.Y., Philosophical Library, 1944. Price $2.50.

In the author's words, this book "aims merely at introducing the reader to the wonder and fascination of the night sky." The result is a satisfactory handbook for the amateur who uses only his naked eyes or very slight optical assistance. The physical side of the subject is little considered; only four lines being devoted to the sun (not visible at night of course), although twelve pages are given to the moon.

After a four-page foreward by Clyde Fisher follow seven chapters which are entitled: Why study astronomy?; The first night out—finding one's bearings; The planets; The moon; Asteroids, comets and meteors; The stars; The galaxy, star clusters and nebulae (58 pages in all).

Appendix I (3 pp.) contains a tabular summary of data relating to the sun, moon and planets; and Appendix II (62 pp.) deals with the constellations and includes four circular star maps and 47 charts. After this is a 2-page glossary of terms and then a 3-page index.

The statements in the book are direct and clear, with little elaboration. Indeed it might be desirable for more explanation in some instances, for example "conjunction" and "occultation" on p. 32. On page 12 the name of the distinguished Hollywood amateur is given as "Hay", instead of "Hays". In the index references to the B.A.A., of which the author is said on the title-page to be a member, are stated to be found on pp. 52 and 54, but do not seem to be there.

C.A.C.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Photograph of an Australian Daylight Meteor

Through the kindness of Professor Griffith Taylor we have received a very interesting paper on a bright daylight meteor. The paper, from the *Proceedings* of the Royal Geographical Society of Australia, South Australian Branch, is by G. F. Dodwell and Charles Fenner. From the reports of many visual observers the authors have computed the path of this detonating fireball.

The meteor was seen on September 7, 1941, at 4.30 p.m. from points over 200 miles apart. A number of the many reports collected are quoted in the article. Amongst the usual features of such reports is that of an observer 140 miles away to whom the meteor "seemed very close." Numerous observers recorded several loud detonations. These were sufficiently loud to alarm people, horses, cattle and birds over a large area.

From both the visual and sound observations the region of probable fall was located as near the centre of an elliptical area three by eight miles, centred near Kybunga, 68 miles north of Adelaide. Standing grain crops and subsequent transportation rationing made the search for meteoritic fragments temporarily quite incomplete. The search did locate, in three separate places, large specimens of tektites, which the authors consider as belonging to the general prehistoric fall of Australites.

The very unusual part of the records concerns the excellent photograph (reproduced in the paper) of the meteor as made by a school teacher, Mr. M. N. Howard, at Nairne. He was taking photographs at the time, saw the meteor moving across the view finder of the camera and "in spite of a certain amount of nervous excitement at the opportunity offered, I was able to press the trigger." Mr. Howard's presence of mind and rapid reaction are most noteworthy. Though he was 82 miles from the meteor, a reconstruction from his photograph permitted a very accurate determination of the altitude and azimuth of the meteor. It is hoped that eventually, with the wealth of visual and sound observations which have been

carefully collected, the authors will be able to proceed with a search for this meteorite.

F.S.H.

THE UNIVERSE HARMONIOUS, NOT CHAOTIC

It lies at the root of our sanity to believe that the nature of the universe is harmonious and not chaotic, and that man, as Quiller-Couch said to his students, is "a part of the Universe and just as surely as the Pleiades or Arcturus." But he was able to continue:

> Moreover he feels in himself a harmony correspondent with the greater harmony of his quest. His heart pumps his blood to a rhythm; like the plants by which he is fed, he comes to birth, grows, begets his kind, enjoys and adorns his day, dies, and returns to earth; and by seasons regulates his life, as summer and winter, seedtime and harvest sweep their circle over him, rhythmical and recurrent, to find him and his house standing, his garden a little better planted, his task a trifle advanced to completion. And then?—why then, of course, he is gone; another has his place and digs his patch. But while his day lasts, the brain just behind his sweating brow is the percipient centre upon which the whole cosmic circle focuses itself as the sun through a burning glass; and he is not shrivelled up by it. On the contrary, he feels that it is all for him. . . .

It is a beautiful and wise passage. The seeming contradictions of our few decades will not uproot it. Perhaps even before this century is gone it will be vindicated, and man be able to look upon the stars, "which are the brain of heaven," and feel again "that it is all for him." Now, he finds it hard to preserve a sense even of communication between himself and "the whole cosmic circle." Since it is no longer true that he "enjoys and adorns his day" or "by seasons regulates his life," he values the evidences of the natural Order not because they are "all for him" but for the opposite reason that their truth is unperjured by his lie. The flowers and the tides and the stars, rhythmical and recurrent, have become for him what letters are to a soldier in a foreign war. They are messages from a preserved Order to his chaos. He loves them, thirsts for them with a desert-thirst, because they, being alive, have yet "the feel of not to feel" that agony of disintegration which, but for them, might seem to him to have befallen the universe.—"Menander's Mirror" in *The Times Literary Supplement.*

Band and Cusps at Occultation of Jupiter

Reports of observations of the occultation of Jupiter on January 13, 1944, have been printed in this Journal, those made at Montreal in the February issue (p. 79) and those made at Edmonton in the April number (p. 171). Apparently on this occasion there were seen some new or rare phenomena, which are discussed in the two notes which follow.

The matter of the grey band during the occultation of Jupiter is developing into a very interesting situation. During the first occultation, although several observers saw the band, I was apparently the only one who saw the "cusps". Now I have a report from Haas, saying that he saw the band during the second occultation, but making no mention of the cusps. (A report by W. H. Haas on observations of the occultation on April 30, 1944, appears in *Popular Astronomy* for May.—*Editor.*) To-day (May 24) I have a letter from King White of Chapman's Camp, B.C. Weather conditions did not permit his observing the second occultation, but he has a letter from Theodore Hake, of York, Penn., U.S.A. Hake and his brother were respectively using a 4½-in. refractor and a 6-in. reflector. They both saw the band, and the cusps. The significant thing is (1) that they were working independently and there was no case of collusion, and (2) that they had *not* heard of my observation at the time.

We are completely at a loss to account for the cusps, which are now confirmed as a real phenomenon. I had a theory that the first occultation took place on the floor of a crater at the moon's limb, and that the cusps were caused by vapour from the walls of the crater rising higher than the vapour on the floor. The Hake observations seem to disprove my theory, as it is hardly likely that the conditions were identical on both occasions. In any case, I am very proud that I was apparently the first to observe these cusps. Pickering seems to have seen the band many years ago.

I regret that I mixed "immersion" and "emersion" in my report to the Journal, but I think anyone will spot the error.

Cyril G. Wates, Edmonton.

In the April issue of this Journal there appeared a report on this occultation as it was observed in Edmonton by Mr. Cyril G. Wates and his associate observers.

Mr. Wates, Dr. Campbell and Mr. White all claim to have observed the blue band separating the planet from the limb of the moon. I observed it at immersion. None of the Montreal observers could observe the emersion, owing to clouds.

I first observed this band when Jupiter was half way behind the moon's disk, the first contact having been obscured by a telephone pole obstructing the

field of the telescope. The band appeared to be the same colour as the sky, making the planet appear quite detached. The band disappeared before last contact.

In suggesting it to be a mirage effect, I was assuming the effect to be due to a lunar atmosphere rather than the earth's atmosphere. Unless the moon's atmosphere is composed entirely of very heavy gases, it must extend to a considerable height on account of the low surface gravity. The narrowness of the band indicates a strong refraction occurring within a few miles of the moon's surface. Such an effect may be produced by the heating by conduction of the lowest portion of the atmosphere by the sunlit surface of the moon which attains a temperature of over 200 degrees.

Similar effects on our own deserts cause objects on the horizon to appear elevated, as though suspended in space. During the occultation it was the image of Jupiter that appeared elevated above the lunar horizon.

As an alternative to the mirage theory I would also suggest that the moon has an atmosphere of only the heaviest gases, such as carbon dioxide, in which case the atmosphere would be much more shallow.

FRANCIS P. MORGAN, Montreal.

C.A.C.

ACADEMIC FREEDOM

Of all the freedoms for which men have struggled, academic freedom is the most precious. It pertains to the chainless mind, not to the body, which may be fettered. In its general sense it has been found not only in academic circles, but in all those rare spirits who have led mankind out of barbaric darkness into light. It was the flame that glowed in Socrates while he drank the hemlock, and in Archimedes when he was slain by Roman legions as he drew geometric figures in the sand. It sustained Galileo in persecution, and Latimer and Ridley as they burned at the stake.

Academic freedom has been maintained in a less heroic manner but on a larger scale by the universities which in recent centuries have been established in rapidly increasing numbers throughout the world. They are generally regarded only as centers of learning; more truly they are places where the mind bows only to commands of the conscience. In far future ages the colleges and universities of our day will be remembered, not so much as places where learning and wisdom flourished, but as oases in which the freedom of the mind was not permitted to die.—F.R.M. in *A.A.A.S. Bulletin.*

MEETINGS OF THE SOCIETY

AT OTTAWA

Report of Open Meetings (1944)—On Wednesday, January 19, the Ottawa Centre held a public lecture at the National Museum on the subject of Calendar Reform. The speaker was Miss Elisabeth Achelis, president of the World Calendar Association, and the title of her address was "The World Calendar".

Miss Achelis made clear the intimate association in all ages of astronomy with the calendar, and said that astronomers particularly realized the defects of the present calendar, though now these were apparent to all other phases of civilized life also. She gave a detailed account of recent attempts at calendar reform, noting that at the League of Nations conference on the matter in 1931 over 500 different plans for reform or change were submitted. These have more or less crystallized into two main plans, the 13-month plan of 28 days and four weeks to every month, and the 12-month plan of identical quarters each having three months of 31, 30, 30 days respectively. The latter is the "World Calendar" favoured by the speaker, who is president of the Association organized to bring it about.

Miss Achelis mentioned Canadians who have been prominent in improvements in the measuring of time, or in calendar reform. Of special interest to the Society was her mention of the work of Dr. H. R. Kingston, a former president of the R.A.S.C.

Not only did Miss Achelis give the many cogent reasons why the World Calendar should be adopted, but also why it should be adopted very soon, either January 1 or July 1, 1945, which were perfect dates for a simple change-over.

A number of questions were asked the speaker after the address; they showed general wide approval of calendar reform, but some difference of opinion as to which method were the better.

Dr. T. L. Tanton, president of the Ottawa Centre, was in the chair and introduced Miss Achelis, mentioning how great an amount of time and effort and money she has for years put into the advancing of the World Calendar. The lecture was very well attended, the Museum Hall being quite filled with an interested audience.

NOTE—This meeting has had an interesting sequel. Because of several enquiries the council felt the need of knowing the members' opinions about calendar reform, etc., and so a little plebiscite was held by means of questionnaires sent out to them. The machinery used was an explanatory covering letter enclosing the questionnaire on a stamped addressed card, to be filled in and returned to the secretary.

The questions asked were simply: Do you approve of calendar reform? Do you approve of the World Calendar? Do you think this Centre should support calendar reform as it sees opportunity to do so? and a space for "Remarks".

A good half of the membership replied—a high percentage for this kind of effort—and examination reveals (a) practically unanimous support for calendar reform; (b) a high majority approval of the World Calendar, but with some members approving of it as a step on the way rather than the final goal; (c) nearly unanimous opinion that the Centre should take such action as it can.

From these results the council of the Ottawa Centre feels justified in asking that other Centres which have not already done so, express themselves on this important matter, and make their opinions known to the General Council in order that it may speak with an informed voice for the whole Society, and with the authority of the Society as a national body. It is important that these matters be attended to soon, if our influence is to be of use in bringing about calendar reform at the time most appropriate for it, the beginning of 1945.

On Friday, March 3, at 8.30 p.m. at the National Museum the Ottawa Centre, this time in collaboration with the Ottawa Branch of the Canadian Institute of Mining and Metallurgy, held a public lecture. Dr. E. A. Hodgson of the Dominion Observatory and Canada's chief seismologist was the speaker, and his subject. "Rockbursts".

(A radio "talk" on this subject was printed in the January issue of the JOURNAL, which may be consulted for further details.—*Editor.*)

Dr. Hodgson illustrated his lecture fully with slides and apparatus. Slides of graphs and charts showed clearly the layout of the mine, and others of seismograph, etc. Records and pictures of Rockbursts showed vividly the power and danger of these disasters. A geophone was set up with an amplifier and the effect illustrated with some crackly cereal in a bottle; this and other small noises sounded terrifying presented in this way and a good deal resembled, Dr. Hodgson said, the sounds the rock gave out when under stress.

A good attendance of about 300 nearly filled the Museum Hall, and all greatly enjoyed Dr. Hodgson's interesting lecture. Dr. T. L. Tanton, President of the Ottawa Centre R.A.S.C. was in the chair and introduced the speaker, and Mr. W. C. McClelland, Chairman of the Ottawa Branch C.I.M.M. thanked him.

F. W. MATLEY, *Secretary.*

AT WINNIPEG

December 9, 1943.—A regular meeting was held in Theatre F, University Building, at 8.15 p.m. The President, Mr. V. C. Jones, in the chair. Attendance 22.

Mr. L. W. Koser was asked to take the chair while Mr. Jones, the retiring president, addressed the meeting on "Counting the Stars and how Galaxies are Co-related," which he illustrated with slides made specially for the occasion, together with blackboard drawings.

Considerable discussion followed in which Messrs. Morse, Norris-Elye,

Crocker, and Koser took part, the latter thanking the speaker for his able presentation of a phase of astronomy that is engaging the attention of many of the leading astronomers of the present.

The Annual Meeting followed, (reports of which have been made) and the newly elected president, Mr. Norris-Elye, thanked the Society for again honoring him with the presidency.

January 13, 1844.—The regular meeting was held at the usual place and time, the president, Mr. Norris-Elye, in the chair. The attendance was rather discouraging as only 18 were present.

Five members reported having observed the occultation of Jupiter and some discussion on this phenomenon was indulged in.

The speaker of the evening was Mr. L. W. Koser, a past president, who gave another of his very informative lectures, in which he outlined the history of astronomy from the time of the Chaldeans, touching upon the outstanding contributions made by the various individuals and countries down to the present time. The members having expressed their appreciation to Mr. Koser by their applause, the meeting adjourned.

February 10, 1944.—The regular meeting was held in Theatre F, University Building, at 8.15 p.m., Mr. Norris-Elye presiding.

A letter was read from Dr. C. A. Chant, acknowledging the Society's message of sympathy to him in the passing of Mrs. Chant, and the members were touched by the warm tribute paid to the many qualities of Mrs. Chant by her bereaved husband.

Mr. T. E. Rasmussen was elected a member of the Society.

The speaker was Fl.-Lt. N. M. Fowler, Command Photograph Officer, No. 2 Training Command, R.C.A.F., who spoke on permissible revelations of the latest developments in aerial photography as applied to the present war. Fl.-Lt. Fowler brought his full equipment with him for demonstration and inspection and delivered a highly interesting and instructive lecture on the technique of getting pictorial proofs essential to the successful prosecution of the war. The members were keenly interested and a great number of questions followed the lecture, after which the apparatus was inspected. The president, Mr. L. T. S. Norris-Elye, thanked the speaker and the meeting adjourned.

March 9, 1944.—The regular meeting was held at the usual time and place, the president, Mr. Norris-Elye, presiding. The attendance continues poor, due partly to the fact that many of the members are engaged in the teaching profession and are called upon to give evening instructions to special classes training for war positions and partly due, no doubt, to the fact that present high nervous tension is adversely affecting many people's desire to engage in serious matters or study not directly connected with their own problems.

The speaker was Professor J. W. Lawson of the University of Manitoba and his subject was "Freedom and Astronomy," in which he sought to show that with

the growth of astronomical knowledge there has come a corresponding freedom from the depressing superstitions and inhibitions that had kept human minds in bondage through attributing adverse natural phenomena to vindictive spirit. Prof. Lawson drew largely from the work of James Harvey Robinson's "The Mind in the Making" and L. S. Stibbing's "Philosophy and the Physicists" and his lecture was both of a constructive and of a critical nature; constructive, in showing mental progress and critical in seeking to put a brake upon questionable hypotheses, or at least, their too-ready acceptance. Many questions were put to Prof. Lawson and were ably explained.

The president thanked the speaker and the meeting adjourned.

April 13, 1944.—The last regular meeting of the Winnipeg Centre was held at the usual time and place. It was announced that Dr. C. S. Beals of the Dominion Astrophysical Observatory would be stopping off on May 25 on his way east and give a lecture to the Centre on "Interstellar Matter." The Society is looking forward to the signal honour and the pleasure of meeting the eminent astronomer.

Mr. H. E. Riter's lecture centred around the "Intergalactic and Extra-galactic Nebulae" and their accepted stages of development. Also the function of the Cepheid variables in determining the distance of various nebulae or extra-galactic systems. By many inter-related tables and diagrams Mr. Riter carried along his difficult subject stage by stage and imparted considerable knowledge on a subject now engaging the attention of many astrophysicists. As evidence of the clearness of his presentation, many questions were inspired on aspects relating to the subject and much discussion took place.

L. W. KOSER, *Press Secretary.*

AT VANCOUVER

January 11, 1944.—The speaker of the evening was Dr. J. G. Hooley of the Chemistry Department of the University of British Columbia, and his topic, "Modern Telescopic Glass".

The speaker first outlined the requirements for the main mirror of a reflecting telescope, and mentioned that the early telescopic mirrors were made of speculum metal. The majority of reflecting mirrors including the 100-inch mirror of the Mt. Wilson telescope are made of plate glass. For the larger 200-inch mirror, now in construction, pyrex glass is more suitable.

An interesting discussion was given regarding the history of the 200-inch mirror. Many experiments were carried out using fused quartz, but the idea of making a mirror of this material was finally abandoned. The speaker explained the engineering problems that had to be met when pouring the glass disc. The poured disc was gradually cooled in an electric annealing furnace over a period of nine months. Polarized light was used to test for the presence of strains in the finished disc. The speaker showed some interesting slides of the manufacture of the large disc.

The composition of various optical glasses used in refracting telescopes and other optical instruments was then explained. New glasses have recently been developed which have desirable optical properties. The lecture concluded with a short discussion of newer glasses used in industry and the home.

February 8, 1944.—The speaker of the evening was Dr. J. Watson of the Department of Physics at the University of British Columbia, and his subject, "Applied Electron Microscopy." Dr. Watson has had considerable experience with the electron microscope at the University of Toronto and is well acquainted with the theory and applications of the instrument.

The speaker first discussed the basic principles regarding the magnetic fields associated with moving charges of electricity. He explained the interaction between magnetic fields, and the paths of electrons near various types of conductors carrying currents of electricity. The analogy between optical and electron microscopes was made clear; in the latter instrument the focussing is brought about by electric and magnetic fields. The speaker demonstrated the focussing of electrons by using a cathode ray oscilloscope. In an optical microscope the useful magnification that can be used is limited by the relatively low resolving power of the instrument. The great advantage of the electron microscope is that the resolving power is high, due to the short effective wavelength of electrons. A much higher useful magnification can then be used.

The lecture was illustrated with a number of slides which showed the great advantage of the electron microscope over the optical type, and gave the audience an idea of the possibilities of the former instrument.

March 14, 1944.—The regular meeting of the Vancouver Centre was held on March 14 in the Science Building at the University. The speaker of the evening was Dr. K. O. Wright of the Physics Department of the University of British Columbia and his subject, "Methods in Stellar Spectroscopy".

The speaker first explained the principles of the formation of absorption lines, and the astronomical instruments used in a study of stellar spectra. He discussed the different parts of the solar atmosphere, and the role that each part plays in the formation of the solar spectrum. The speaker then gave a short historical account of spectral classification.

Dr. Wright briefly explained the origin of spectral lines on modern atomic theory. He then mentioned a few of the problems concerned with stellar spectra such as the determination of stellar temperatures and relative abundances of elements. The speaker explained the methods used in measuring line intensities. The first step is always to obtain the characteristic curve of the emulsion used by means of a step-slit, step-wedge or rotating log sector. He concluded with a summary of the information that can be obtained from stellar spectra regarding temperatures and densities in stellar atmospheres.

WILLIAM PETRIE, *Recorder.*

The Royal Astronomical Society of Canada

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